DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

PROBLEMS OF PROGRESS IN INDUSTRY—5

MANAGEMENT AND TECHNOLOGY

by Joan Woodward

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Preface

THE OBJECT of this new series is to present briefly and simply the results of new research into the social, economic and technical problems of industrial progress—problems arising from automation and other advances in techniques, and problems of management and human relations. The booklets are either 'industrial versions' of academic reports that have been or soon will be published elsewhere; or short reviews of research done independently by several teams. The series is planned in the belief that responsible officials on both sides of industry feel the need to digest and use new research material but have not the time to browse through full-length volumes.

The series is commissioned and edited by the Department of Scientific and Industrial Research, which seeks only to provide a forum for responsible new thinking and to stimulate independent discussion and action, including further research. The conclusions and speculations are those of the investigators, mostly from the universities and other well-known research bodies.

This issue is based on a survey of the management organization of a hundred firms in south Essex, and on a number of case studies supplementary to the survey. The studies were made by the members of the Human Relations Research Unit of the South East Essex Technical College: Joan Woodward, R. S. Webster, J. Batstone, and M. Sanderson. This unit was supported by the Department of Scientific and Industrial Research with counterpart funds derived from U.S. Economic Aid.

It is hoped that a full report of the research, together with a discussion of its theoretical implications for management studies, will be published shortly under the title *Management Organization: Theory and Practice*. This short and selective summary is not a substitute for the full report, but an outline of the important findings. Many conclusions are omitted, as are many of the facts on which they are based and many detailed reservations that limit their applicability to other situations.

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August, 1958

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I. Introduction

THE RESEARCH DESCRIBED in this booklet was the first attempt in Britain to discover whether the principles of organization laid down by an expanding body of management theory correlate with business success when put into practice.

It was carried out between 1953 and 1957 by the Human Relations Research Unit of the South East Essex Technical College. The original intention of the research workers was to look at the division of responsibilities between line supervision and the technical specialists who apply technology to the production process, and at the factors which determine the relationships between them. They soon found, however, that this line-staff relationship could not be studied in isolation, so they widened their investigations to include the whole structure of management and supervision. Their basic survey in 91 per cent of the manufacturing firms in south Essex with over 100 employees revealed considerable variations in the pattern of organization which could not be related to size of firm, type of industry or business success.

When, however, the firms were grouped according to similarity of objectives and techniques of production, and classified in order of the technical complexity of their production systems, each production system was found to be associated with a characteristic pattern of organization. It appeared that technical methods were the most important factor in determining organizational structure and in setting the tone of human relationships inside the firms. The widely accepted assumption that there are principles of management valid for all types of production systems seemed very doubtful—a conclusion with wide implications for the teaching of this subject.

After completing the survey the team studied more fully twenty firms selected along a scale of technical complexity, and made detailed case studies of three firms in which production systems were mixed or changing.

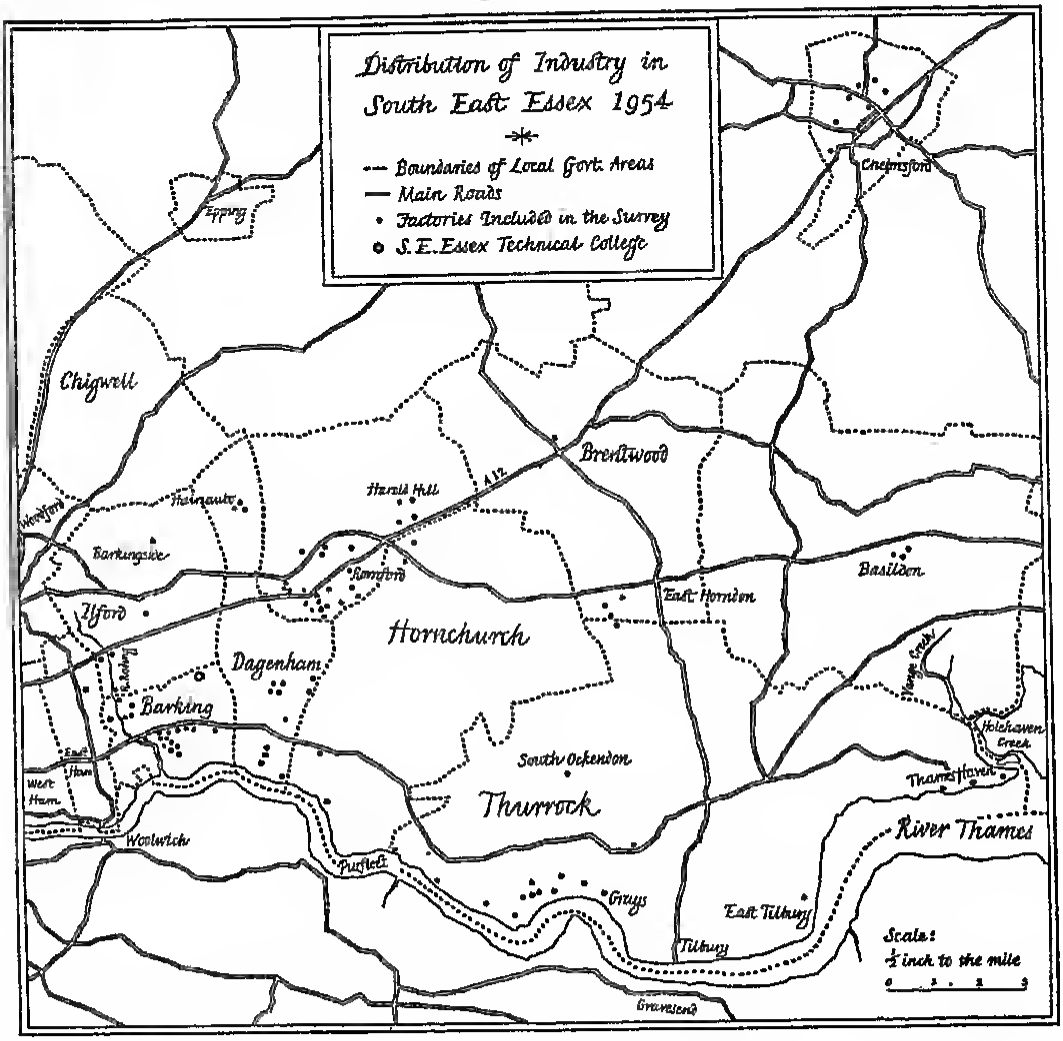
This summary covers all three stages of the research. It describes the background survey, giving enough of the information collected to show some of the main differences between the organizational patterns associated with each of the different

systems of production. The more descriptive information obtained in the second stage of the research is used to provide explanations of these differences. Finally, the detailed case studies are briefly referred to and an attempt is made to show how the analysis of changes in technical demands due to innovation can help to solve in advance the problems of management organization likely to arise.

II. The Survey

The area

The map shows the area covered by the survey. Industrial development came comparatively late to south Essex and newer



industries such as oil refining, wireless, photography, pharmaceuticals, paperboard and vehicles predominate. Factory buildings are on the whole modern. So is management organization. Most factories here were built when the functions of ownership and management had already been separated and there are few long-established family businesses. A number of family firms did move here, but their history suggests that the move gave most of them an occasion for radical changes in management structure.

The firms

The investigation was confined to manufacturing firms in the area. Those concerned with mining and quarrying, building contracting and laundering were excluded, as were transport undertakings, public utilities and local authorities.

A long search produced a list of 203 manufacturing firms which was as comprehensive as humanly possible; it is unlikely that any firm employing 100 people or more was omitted.

The number employed ranged from a dozen to approximately 35 000. (See Table I.)

TABLE I. SIZE DISTRIBUTION OF MANUFACTURING FIRMS IN SOUTH ESSEX

FIRMS EMPLOYING	PERCENTAGE OF 203 FIRMS	PERCENTAGE OF LABOUR FORCE (119 400)
100 or less	46	3
101–250	24	7
251–500	12	8
501–1000	9	11
1001–2000	4	10
2001–4000	3	14
4001–8000	1	9
8000 and over	1	38
Totals	100	100

There are more large firms in south Essex than in the country generally, 9 per cent employing more than 1000 people as against 1.7 per cent overall. The 203 firms cover a wide range of industries. In most of them the number employed in the area represents between 1 and 2 per cent of the national total. In

textiles and leather the percentage is particularly low, but in vehicles and chemicals it is as high as 7 per cent.

A 25 per cent sample survey of the 93 firms employing less than 100 people showed no clear-cut level of management between board and operators in most of them. The main survey was therefore confined to the 110 firms employing 100 people or more, of which 100, or 91 per cent, were willing and able to take part.

Of these 100 firms, 68 had both their main establishment and their commercial headquarters inside the area; the rest had only branch factories.

Information obtained

A research worker visited each of the firms and obtained information under the following headings:

1. History, background and objectives.
2. Description of the manufacturing processes and methods.
3. Forms and procedures through which the firm was organized and operated.
   (a) An organization chart.
   (b) A simple analysis of costs into three main divisions: wages, materials, and overheads.
   (c) An analysis of the labour structure, including the size of the span of control at various levels and the following ratios:
      (i) Direct production workers to total personnel.
      (ii) Maintenance workers to direct production workers.
      (iii) Clerical and administrative to hourly paid personnel.
      (iv) Managers and supervisory staff to total personnel.
   (d) The organization and operation of sales activities, research and development, personnel management, inspection, maintenance, and purchasing.
   (e) The procedures used in production control and planning.
   (f) The procedures used in cost or budgetary control.
   (g) The qualifications and training of managers and supervisory staff; management recruitment and training policy.

4. Information helpful in making an assessment of the firm's efficiency.

The assessment of efficiency

It is not easy to assess either the success of a firm or the effectiveness of a particular administrative expedient. The circular argument that an arrangement works because it exists is difficult to avoid. But an assessment was attempted. The firms were classified into three broad categories of success: average, below average and above average. The more obvious factors considered were profitability, market standing, rate of development and future plans. Questions were asked about the unit of measure commonly applied to the product, the volume of the industry's output, the proportion of that volume produced by the firm concerned, and the nature of the market. More subjective factors considered included the reputation of the firm, both inside its industry and among local firms, the quality and attitudes of its management and supervisory staff, the rate of this staff's turnover, and the opportunity provided for a complete and satisfying career in management.

III. Results

Organizational differences between firms

The 100 firms in the survey were organized and run in widely different ways. In only about half did the principles and concepts of management theory appear to have had much influence on organizational development.

In 35 firms there was an essentially 'line' or 'military' type of organization; two firms were organized functionally, almost exactly as recommended by Taylor fifty years ago.* The rest followed in varying degrees a line-staff pattern of organization; that is, they employed a number of functional specialists as 'staff' to advise those in the direct line of authority.

* F. W. Taylor, *Shop Management*, Harper Bros., New York–London, 1910.

The number of distinct levels of management between board and operators varied from two to twelve; while the span of control of the chief executive* ranged from two to nineteen, and that of the first line supervisor† from seven to ninety. (An individual's span of control is the number of people directly responsible to him.)

Wages and salaries accounted for anything between 3 per cent and 50 per cent of total costs. Labour forces differed in character from firm to firm too; for example, the ratio of clerical and administrative staff to hourly paid workers ranged between 3 : 1 and 1 : 14; and that of direct to indirect labour between 1 : 3 and 15 : 1. Exactly half of the firms employed graduates or other professionally qualified staff. Thirty firms promoted their managers entirely from within, five from outside only, and the remainder used both sources according to circumstances.

There was no obvious explanation of these differences in organizational structure; they did not appear to be related either to size or type of industry. Also, conformity with the 'rules' of management did not necessarily result in success or non-conformity in commercial failure. Of the twenty firms assessed as 'above average' in success, only nine had a clearly defined organizational pattern of the orthodox kind.

New ideas about management

Did any common thread underlie these differences? One possible explanation was that they reflected the different personalities of the senior managers, another that they arose from the historical background of the firms. While such factors undoubtedly influenced the situation, they did not adequately explain it; they were not always associated with differences in organizational patterns or in the quality of human relations.

A new approach lay in recognizing that firms differed not only in size, kind of industry and organizational structure, but also in

* The chief executive was in some cases the Chairman, in others the Managing Director, and in others the General or Works Manager. In every case he represented the highest level of authority operating full-time on the spot.

† i.e. the first level of authority that spent more than 50 per cent of the time on supervisory duties.

objectives. While the firms were all manufacturing goods for sale, their detailed objectives depended on the nature of the product and the type of customer. Thus some firms were in more competitive industries than others, some were making perishable goods that could not be stored, some produced for stock, and others to orders; in fact, marketing conditions were different in every firm. The underlying purpose varied too. For example, one firm had originally undertaken manufacture to demonstrate that the products of its mines could be effective substitutes for other more commonly used materials.

These differences in objectives controlled and limited the techniques of production that could be employed. A firm whose objective was to build prototypes of electronic equipment, for example, could not employ the technical methods of mass-production engineering. The criterion of the appropriateness of an organizational structure must be the extent to which it furthers the objectives of the firm, not, as management teaching sometimes suggests, the degree to which it conforms to a prescribed pattern. There can be no one best way of organizing a business.

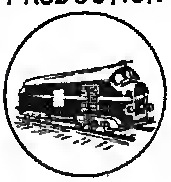
This is perhaps not sufficiently recognized; management theorists have tried to develop a 'science' of administration relevant to all types of production. One result is that new techniques such as operational research and the various tools of automation have been regarded as aids to management and to industrial efficiency rather than as developments which may change the very nature of management.

Evidence is accumulating, particularly in the United States, that automation and other technological changes are often associated with considerable disturbance in the management systems of the firms concerned. New tools begin to change the task and the new task begins to change the organization and the qualities required to carry it out successfully. For example, work done in the United States has shown that the qualities required of the foreman on a motor-car assembly line appear to be very different from those required on transfer-line production.* Expressions like 'leadership' or 'the art of foremanship', used so often in management literature, are losing much of their meaning. It is possible, for example, that leadership must be

* *The Man on the Assembly Line*, Charles R. Walker and Robert H. Guest (Cambridge, Mass: Harvard University Press, 1952).

PRODUCTION SYSTEMS IN SOUTH ESSEX INDUSTRY

GROUP I
SMALL BATCH AND UNIT PRODUCTION



I Production of simple units to customers' orders (5 firms)

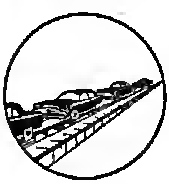
II Production of technically complex units (10 firms)

III Fabrication of large equipment in stages (2 firms)

IV Production of small batches (7 firms)

V Production of components in large batches subsequently assembled diversely (3 firms)

GROUP II
LARGE BATCH AND MASS PRODUCTION



VI Production of large batches, assembly line type (25 firms)

VII Mass production (6 firms)

VIII Process production combined with the preparation of a product for sale by large-batch or mass-production methods (9 firms)

GROUP III
PROCESS PRODUCTION

IX Process production of chemicals in batches (13 firms)

X Continuous flow production of liquids gases and solid shapes (12 firms)

(8 firms unclassified because too mixed or changing)

FIGURE I

directive, participant, or *laissez-faire* according to circumstances. A good leader in one situation is not necessarily a good leader in another.

Two interesting questions have so far emerged. Are the management organization and supervisory qualities required in a firm in the process of radical technical change different from those required in a stable firm? Does the kind of organization required vary with the technical complexity of the manufacturing methods?

Differences in technical methods

The firms were grouped according to their technical methods. Ten different categories emerged. (See Figure 1, p. 11.)

Firms in the same industry did not necessarily fall into the same group. For example, two tailoring firms of approximately equal size had very different production systems; one made bespoke suits, the other mass-produced men's clothing.

Measurement of technical complexity

The ten production groups listed in Figure 1 form a scale of technical complexity. (This term is used here to mean the extent to which the production process is controllable and its results predictable). For example, targets can be set more easily in a chemical plant than in even the most up-to-date mass-production engineering shops, and the factors limiting production are known more definitely so that continual productivity drives are not needed.

Some of the firms studied used techniques of operational research to increase control over production limitations—but these could be effective only within limits set by technical methods, which were always the major factor determining the extent of control over production.

Production systems and technical progress

Grading firms according to their technical complexity implies no judgment of their progressiveness or backwardness, nor is it any indication of the attitude of their managements towards technical innovation. Each production system has its particular applications and limitations. While there remains a demand for the gold-plated limousine or the bespoke suit, while large items of

equipment have to be built, or while progress in industries like electronics proceeds too rapidly to permit standardization, there will be a place for unit production even though it is less advanced technically than other systems. Moreover, although continuous-flow production is applicable to the manufacture of single components, it is difficult as yet to foresee its use where many different component parts are assembled.

However, technical developments may from time to time enable a firm to achieve its objectives more effectively through a change in its production system, and a large proportion of manufacturing firms in the future are likely to be process firms. Indeed, although large-batch and mass production is regarded as the typical manufacturing system, less than one third of the firms in south Essex are even now in this production group.

Automatic and other advanced techniques, although more appropriate to some systems than others, are not restricted to any one system. Automatic control can be applied most readily to mass production and continuous-flow process production, but even in unit and small-batch production devices for the control of individual machines can be used.

Sixteen of the firms included in the research had introduced some form of automation. In some of them, for example in those canning food and making mill-board, the production system had changed in consequence; in others it had not. Thus automation can be introduced without a change in the production system, and a change in the production system can be introduced without automation.

THE NUMBER OF LEVELS OF AUTHORITY IN MANAGEMENT HIERARCHY

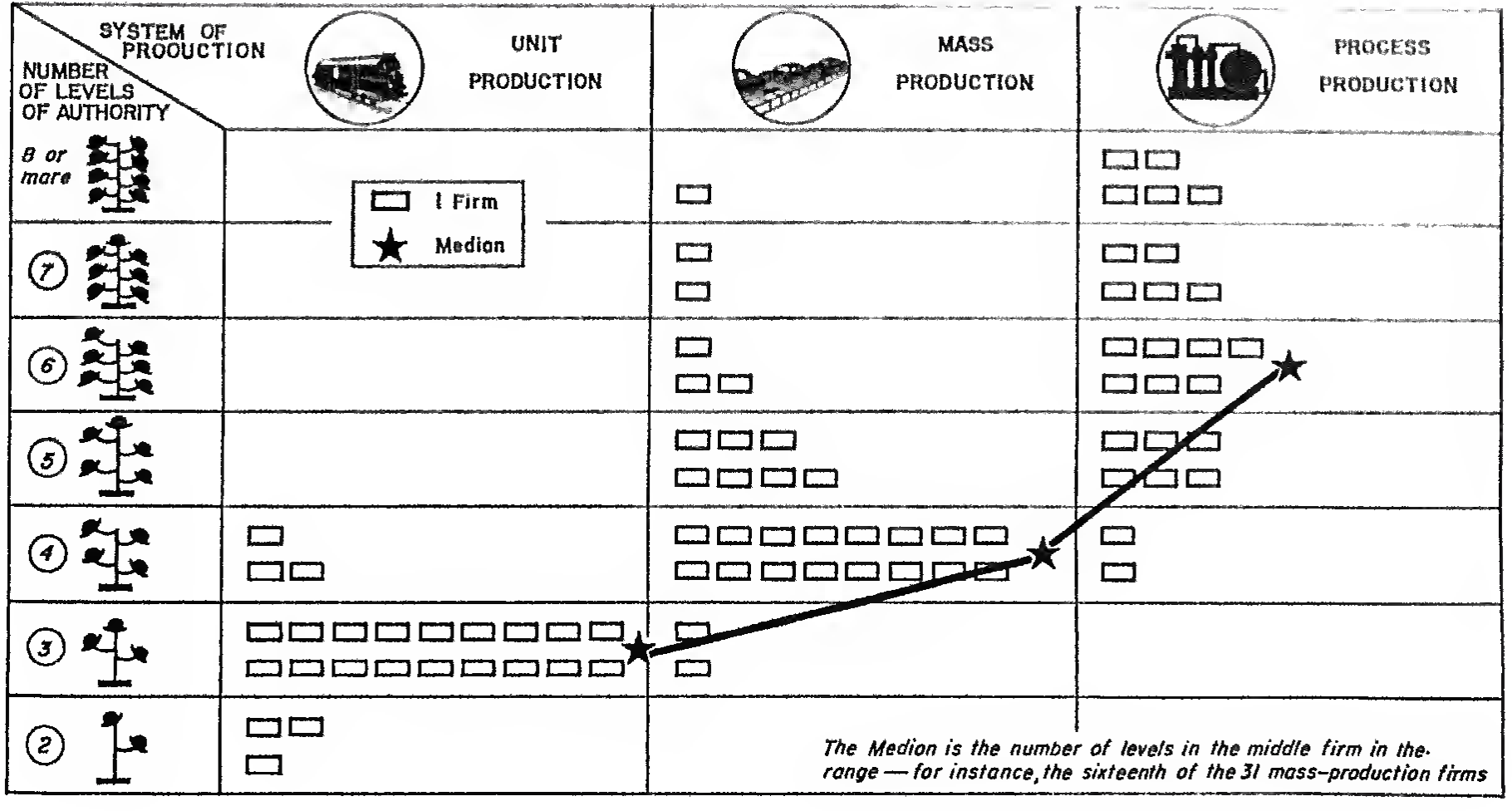


FIGURE 2

SPAN OF CONTROL OF FIRST LINE SUPERVISION

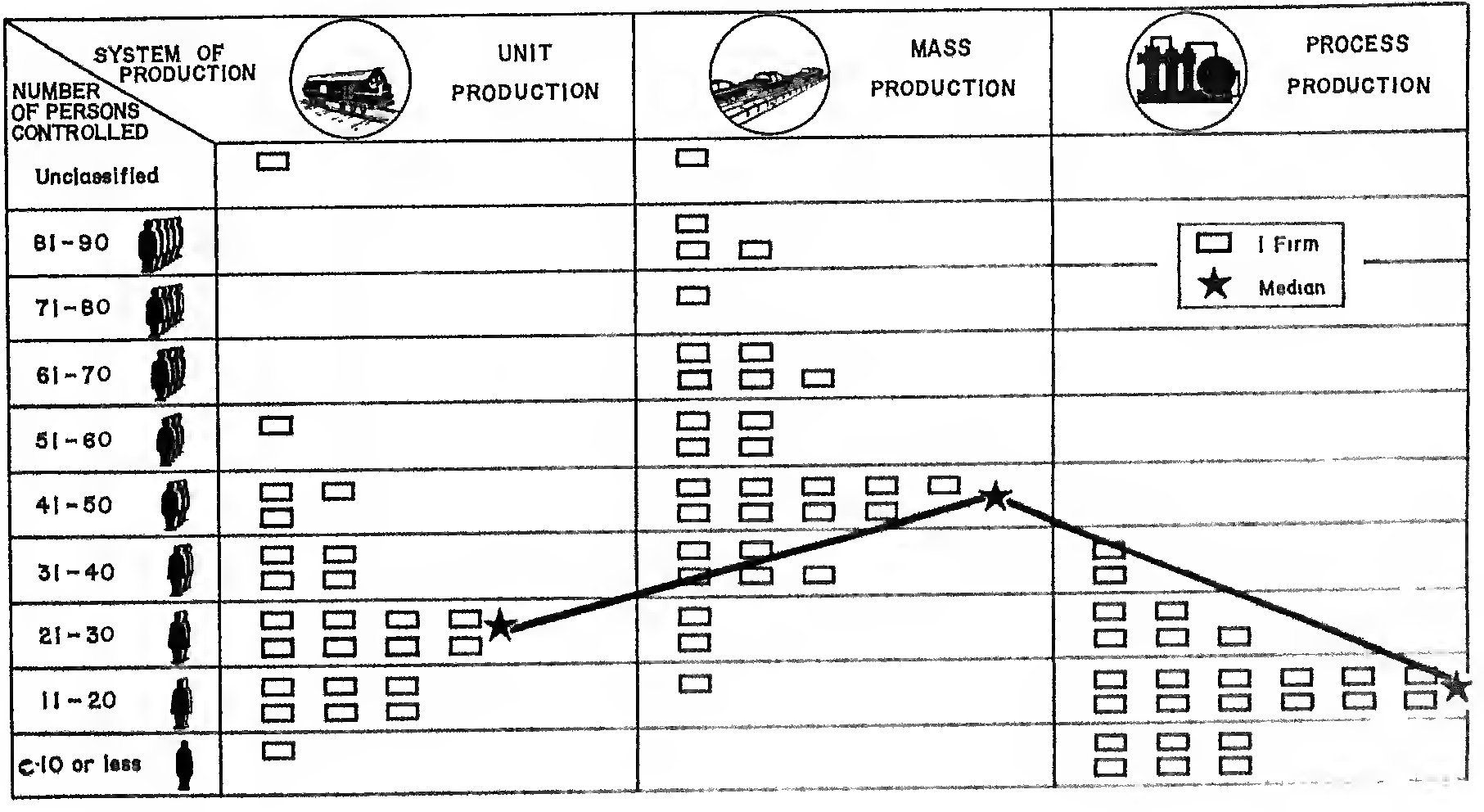


FIGURE 3

IV. Organization and Technology

The analysis of the research described in the previous chapter revealed that firms using similar technical methods had similar organizational structures. It appeared that different technologies imposed different kinds of demands on individuals and organizations, and that these demands had to be met through an appropriate form of organization. There were still a number of differences between firms—related to such factors as history, background, and personalities—but these were not as significant as the differences between one production group and another and their influence seemed to be limited by technical considerations. For example, there were differences between managers in their readiness to delegate authority; but in general they delegated more in process than in mass-production firms.

Organization and technical complexity

Organization also appeared to change as technology advanced. Some figures showed a direct and progressive relationship with advancing technology (used in this report to mean 'system of techniques'). Others reached their peak in mass production and then decreased, so that in these respects unit and process production resembled each other more than the intermediate stage. Figures 2 and 3 show these two trends. (Details are given for the three main groups of production systems. See Figure 1, p. 11.)

The number of levels of authority in the management hierarchy increased with technical complexity. (See Figure 2, p. 14.)

The span of control of the first-line supervisor on the other hand reached its peak in mass production and then decreased. (See Figure 3, p. 15.)

The ratio of managers and supervisory staff to total personnel in the different production systems is shown in some detail in Figure 4 as an indication of likely changes in the demand for managers as process production becomes more widespread. There were over three times as many managers for the same number of personnel in process firms as in unit-production firms. Mass-production firms lay between the two groups, with half as many

managers as in process production for the same number of personnel.

The following characteristics followed the pattern shown in Figure 2—a direct and progressive relationship with technical complexity.

1. *Labour costs* decreased as technology advanced. Wages accounted for an average of 36 per cent of total costs in unit production, 34 per cent in mass production and 14 per cent in process production.

2. *The ratios of indirect to direct labour* and of administrative and clerical staff to hourly paid workers increased with technical advance.

3. *The proportion of graduates* among the supervisory staff engaged on production increased too. Unit-production firms employed more professionally qualified staff altogether than other firms, but mainly on research or development activities. In unit-production and mass-production firms it was the complexity of the product that determined the proportion of professionally qualified staff, while in process industry it was the complexity of the process.

4. *The span of control of the chief executive* widened considerably with technical advance.

The following organizational characteristics formed the pattern shown in Figure 3. The production groups at the extremes of the technical scale resembled each other, but both differed considerably from the groups in the middle.

1. *Organization was more flexible* at both ends of the scale, duties and responsibilities being less clearly defined.

2. The amount of *written, as opposed to verbal, communication* increased up to the stage of assembly-line production. In process-production firms, however, most of the communications were again verbal.

3. *Specialization between the functions of management* was found more frequently in large-batch and mass production than in unit or process production. In most unit-production firms there were few specialists; managers responsible for production were expected to have technical skills, although these were more often based on length of experience and on 'know-how' than on scientific knowledge. When unit production was based on mass-produced components more specialists were employed however.

Large-batch and mass-production firms generally conformed to the traditional line-and-staff pattern, the managerial and supervisory group breaking down into two sub-groups with separate, and sometimes conflicting, ideas and objectives. In process-production firms the line-and-staff pattern broke down in practice, though it sometimes existed on paper. Firms tended either to move towards functional organization of the kind advocated by Taylor*, or to do without specialists and incorporate scientific and technical knowledge in the direct executive hierarchy. As a result, technical competence in line supervision was again important, although now the demand was for scientific knowledge rather than technical 'know-how'.

4. Although production control became increasingly important as technology advanced, *the administration of production*—what Taylor called 'the brainwork of production'—was most widely separated from the actual supervision of production operations in large-batch and mass-production firms, where the newer techniques of production planning and control, methods engineering and work study were most developed. The two functions became increasingly reintegrated beyond this point.

The effect of technology upon human relations

The attitudes and behaviour of management and supervisory staff and the tone of industrial relations in the firms also seemed to be closely related to their technology. In firms at the extremes of the scale, relationships were on the whole better than in the middle ranges. Pressure on people at all levels of the industrial hierarchy seemed to build up as technology advanced, became heaviest in assembly-line production and then relaxed, so reducing personal conflicts. Some factors—the relaxation of pressure, the smaller working groups, the increasing ratio of supervisors to operators, and the reduced need for labour economy—were conducive to industrial peace in process production. Thus, although some managements handled their labour problems more skilfully than others, these problems were much more difficult for firms in the middle ranges than those in unit or process production. The production system seemed more important in determining the quality of human relations than did the numbers employed.

* Op. cit.

THE RATIO OF MANAGERS AND SUPERVISORY STAFF TO OTHER PERSONNEL

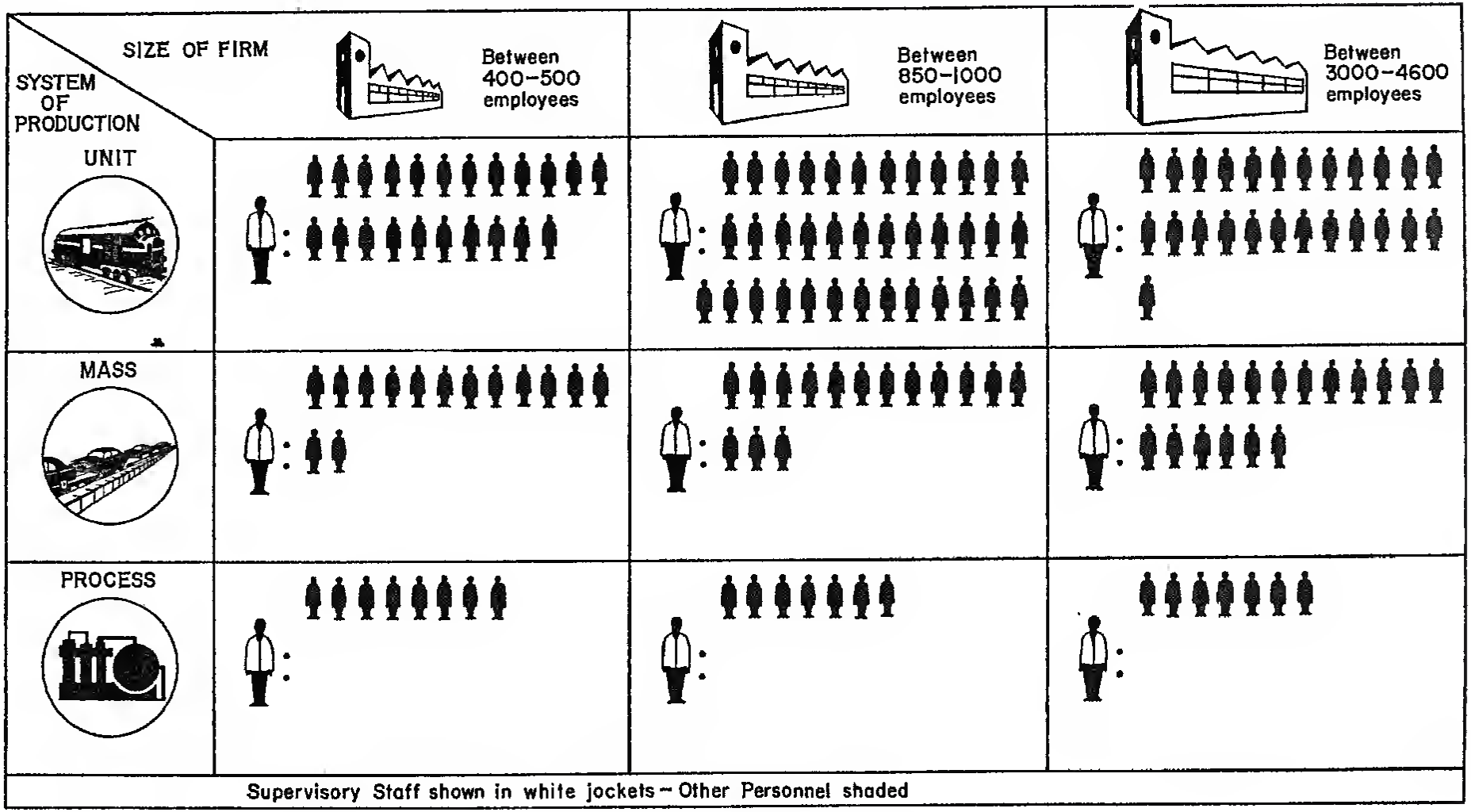


FIGURE 4

Size and technology

No significant relationship was revealed between the size of the firm and the system of production. There were small, medium, and large firms in each of the main production groups.

TABLE II. PRODUCTION SYSTEMS ANALYSED BY NUMBER EMPLOYED

PRODUCTION SYSTEM	NUMBER EMPLOYED: 101–250	251–1000	OVER 1000	TOTAL NUMBER OF FIRMS
Unit	7	13	4	24
Mass	14	12	5	31
Process	12	9	4	25
Totals	33	34	13	80

There were firms which employed relatively few people and yet had all the other characteristics of a large company, including a well-defined and developed management structure, considerable financial resources, and a highly paid staff with considerable status in the local industrial community. This was particularly true of the smaller process-production firms. Some of these employed less than 500 people but had more of the characteristics of large-scale industry than unit- or mass-production firms with two or three times as many employees. As indicated already (p. 16) the ratio of management staff to the total number employed was found to increase as technology advanced. It appeared also that the size of the management group was a more reliable measure of the 'bigness' of a firm than its total personnel.

Moreover, although no relationship was found between organization and size in the general classification of firms, some evidence of such a relationship emerged when each of the production groups was considered separately. For example, in the large-batch and mass-production group the number of levels of authority and the span of control of both the chief executive and the first line supervisor both tended to increase with size.

Structure and success

Again, no relationship between conformity with the 'rules' of management and business success appeared in the preliminary

analysis of the research data. The twenty firms graded as outstandingly successful seemed to have little in common.

When, however, firms were grouped on a basis of their production systems, the outstandingly successful ones had at least one feature in common. Many of their organizational characteristics approximated to the median of their production group. For example, in successful unit-production firms the span of control of the first line supervisor ranged from 22 to 28, the median for the group as a whole being 23; in successful mass-production firms it ranged from 45 to 50, the median for the group being 49; and in successful process-production firms it ranged from 11 to 15, the median for the group being 13. (See Figure 3, p. 15.) Conversely the firms graded as below average in most cases diverged widely from the median.

The research workers also found that when the 31 large-batch- and mass-production firms were examined separately there was a relationship between conformity with the 'rules' of management and business success. The medians approximated to the pattern of organization advocated by writers on management subjects. Within this limited range of production systems, therefore, observance of these 'rules' does appear to increase administrative efficiency. This is quite understandable because management theory is mainly based on the experience of practitioners in the field, much of which has been in large-batch and mass-production firms. Outside these systems, however, it appears that new 'rules' are needed and it should be recognized that an alternative kind of organizational structure might be more appropriate.

V. The Follow-up Studies

The organizational demands of production systems

What are the demands made by different technical methods? Is it possible to trace a relationship between a system of production and its associated organization pattern? To find answers to such questions as these, twenty of the firms included in the survey were picked out at intervals along the scale of technical complexity and studied in more detail. They included six unit or small-batch production firms, six large-batch or mass-production firms, five process-production firms, and three in which process production was combined with preparation of the product for sale by large-batch or mass-production techniques.

In each firm the research workers studied:

(1) The manufacturing process itself, analysing the subsidiary tasks necessary to the achievement of primary objectives.

(2) The number and nature of the decisions that had to be taken at each level of the management hierarchy.

(3) The kind of co-operation required between the various members of the management team.

(4) The kind of control which had to be exercised by senior executives.

The research workers then made an analysis of what they term the 'situational demands' in each firm. This means the demands on the organization of the technical situation, the system of techniques imposed by the firm's objectives. (See also p. 25.) They also considered what organizational and operational expedients were likely to be effective in meeting the demands and how far the firms' existing organizational structures did in fact meet them.

The conclusions which follow derive both from these follow-up studies and from the case studies described on pp. 31–6.

The relationship between the functions of management

A breakdown of management into its basic functions—development, production and marketing—revealed that the character of the functions, their chronological sequence, the closeness with which they had to be integrated and their relative importance to

the success and survival of the business, all depended upon the system of techniques in the firm concerned.

(a) *Character and sequence*

In *unit-production* firms the manufacturing cycle began with the marketing function; the initial task of management was in most cases to obtain an order. Those responsible for marketing had to sell, not a product, but the idea that their firm was able to produce what the customer required. The product was developed after the order had been secured, the design being, in many cases, modified to suit the requirements of the customer. Production itself was the final stage in the manufacturing process.

In *mass-production* firms the sequence appeared more logical; product development came first, then production, and finally marketing. It is true that in the long run research and development programmes and production schedules must depend on information passed back by the selling staff. But although passing back information was often an important part of the salesman's job, his basic task remained in every case the disposal of goods already produced. He had to persuade the customer, not that the firm was capable of producing what he wanted, but that he wanted what the firm was capable of producing.

In *process production* too, product development was the first stage of manufacture. In this kind of industry the development of a product often implied the development of a process, product and process being interdependent. Here, however, the newly developed product was usually marketed when it reached the pilot stage, for production was not normally started on a large scale until an assured market had been found. In the chemical industry, for example, the history of penicillin production is unusual; only in exceptional cases is there a market waiting to absorb a new product. Normally pharmaceutical chemicals are produced on an experimental basis by the manufacturers and the medical profession tests them before they are produced in quantity.

(b) *Co-ordination*

Unit production appeared to demand co-ordination between functions on a day-to-day operational basis. In several firms product development was indistinguishable from production itself. In

bespoke tailoring, for example, the cutter developed and produced at the same time, adjusting designs during manufacture to suit individual requirements.

Mass-production firms had elaborate and extensive research and development programmes, but staff responsible for research were not involved in day-to-day production problems or marketing activities. Any policy decisions taken as a result of their work were long-term and far-reaching and often involved considerable expenditure; thus they were taken only at the highest level of management. In some cases the functions were physically separated, research and development being undertaken on a separate site. In others, firms did no research or development at all; they relied for new ideas on outside research bodies or on more informal sources. But although day-to-day integration of functions did not appear to be necessary, and could be dangerously disruptive, co-operation in exchanging information was essential. Product-development staff relied upon information from marketing about the way customers were thinking and from production about manufacturing facilities for the new products. (All this refers only to research relating to the product and not to the development of production methods. Methods research is an integral part of the production function and obviously must be closely integrated with other production activities.)

In *process production* too, functions were in many cases independent of each other, though not as clearly as in mass production, because of the close relationship between product development and process development. More fundamental research on new products was almost entirely self-contained. It was not controlled by existing production facilities or by customers' requirements; indeed, in many cases a market had yet to be found. When development reached the pilot-plant stage, however, closer integration was required between research and production; in some cases this was needed on the job itself, in others co-operation in exchanging information was sufficient.

But while more co-ordination of the three basic tasks was normally required in unit production than in mass or process production, it was occasionally required in the two latter. For instance, in process production, development staff were required to work closely with marketing personnel when creating a market for a new product. In both process and mass production,

development staff had to co-operate with production personnel when bringing a new product into large-scale manufacture.

(c) *Relative importance*

In *unit-production* firms, all other activities were centred round, and dependent upon, development. The skill and ingenuity of those responsible for development were the most important factors in ensuring the firm's success.

In *mass-production* firms, production itself was the central activity. Success depended almost entirely on the efficient administration of production and the progressive reduction of unit costs.

In *process-production* firms, success depended largely on the existence of a market waiting to absorb the products, as storage of their products was often difficult or impossible. The rate of absorption determined indirectly the production flow; and, as a chemical plant that is working to full capacity is both more economical and easier to operate, much depended upon the efficiency of the marketing organization.

'Situational demands'

This discussion clarifies the action of 'situational demands'. For example, each technical situation requires a different kind of co-operation between the members of a management team. Consequently the system of communication through which co-operation is brought about must also differ from one situation to another. Communications systems cannot be good or bad in themselves; they are good only if they link people together in such a way as to further the objectives of the firm. Thus unit production requires a communication system which brings people together on a day-to-day operational basis; but in mass and process production such a system might well reduce efficiency.

The same principles apply if the basic tasks of development production and marketing are broken down into their constituent functions. The nature of these functions, their relative importance and the relationship between them, all vary with the technical demands of the process. For example, inspection, which is a function of production management, has relatively little importance in the earlier stages of technology. The sense of responsibility and the satisfaction obtained from the production of individual units are sufficient to maintain a reasonably high

standard. In large-batch and mass production inspection becomes very important. In the more complex technologies it loses importance, however, as self-correcting and control devices become increasingly incorporated in the process itself. Similar patterns can be traced for other functions, including personnel, purchasing, and plant maintenance.

Management decisions

The number and nature of the decisions that had to be made also depended on the technical demands of the manufacturing process.

In *unit production:*

(a) More decisions had to be made here than in other kinds of production, all of them relatively short-term and almost equal in importance. In many a firm a policy decision had to be made each time an order was accepted, but it committed the firm only for the period in which that article was produced. For large equipment such as television transmitters, the period could be as long as several years; even so it was shorter than that of many decisions in mass and process production.

(b) There was little distinction between policy decisions and problem-solving decisions, a problem-solving decision almost inevitably developing into a policy decision.

(c) A large proportion of the decisions made affected all the basic functions of manufacture. For example, when a raw material supply failed, the decision to use a substitute involved not only those concerned with production activities but also the development and marketing personnel; sometimes it was even necessary to reopen negotiations with the customer, too.

In *mass production*, decisions were more varied both in character and importance:

(a) Policy decisions about objectives, and the activities essential to achieving these objectives, were fewer but usually of greater importance than in unit production because they committed the firm further into the future and had to be based on a wider variety of background facts.

(b) Problem-solving decisions did not develop into policy decisions as often as they did in unit-production firms.

(c) As the basic functions of manufacture were more independent of each other, policy decisions sometimes affected one function only and could often be taken by the senior executive responsible for that function. The planning of a territorial sales organization, for example, normally involved decisions by the marketing personnel only. (One exception to this was found, however, in a firm where the area sales managers were linked with production units located in various parts of the country. Thus, any change made in the organization of the sales force affected the schedules of the production units and was therefore based on a joint decision of the two senior executives responsible for marketing and production respectively.)

(d) Decisions were also more predictable—not their exact content, of course, but at least the kind of decisions likely to occur.

In *process production:*

(a) Policy decisions were fewer than in mass or unit production but committed the firms concerned further into the future. One firm was planning to erect a new plant which, it was estimated, would take three years to build and twenty years to give an adequate return on the investment. Production facilities, once determined, would be extremely inflexible, as in most other chemical plants. Success would depend, therefore, on an assured market for the product during the next twenty years. Even in process industry not all policy decisions were as long-term as this; nevertheless, many were too important to be the responsibility of one individual. The organizational framework had to allow for joint decisions by senior management and more of the decisions were made at board level than in other systems.

(b) Problem-solving decisions, on the other hand, had to be made as near as possible to the point at which the crisis occurred; they were normally associated with operational difficulties and were of great urgency. Policy decisions were even more distinct from problem-solving decisions than in mass production.

(c) Making decisions became an increasingly rational process. The imponderables became progressively fewer and the consequences of a particular course of action could be foreseen more exactly; management hunches were required less and less. This is probably the most important single factor linking technology with organization, and it has far-reaching implications.

Effects of increased rationality in process production

Discussions with managers and supervisors showed that this increased rationality in decision-making meant that:

(1) Any two individuals, having similar qualifications and background training and knowing the same set of facts, tended to make the same decisions, except on the relatively few occasions where value judgments were involved. This made it much easier to delegate responsibility for decision-making. In less technically advanced industry managers were often afraid that decisions made by their subordinates might embarrass them. They found delegation easier if they could be confident that over a wide area their subordinates would make much the same decisions as themselves.

(2) Decisions rarely got reversed at every stage up the hierarchy as they did in unit and mass production. The result was that in process production far greater feelings of satisfaction and independence were associated with lower management responsibilities.

(3) Joint policy decisions at board level were more easily reached; moreover they tended to be those of which junior management approved and would have made themselves in similar circumstances. There was a marked trend towards the Executive Board, consisting of a high proportion of technically qualified directors, and management by committee appeared to work better. Another marked characteristic was the absence of an authoritarian personality at the top.

(4) Because responsibility for problem-solving decisions was extensively delegated, and responsibility for major policy decisions was retained at board level, the senior executive in process industry appeared to make far fewer decisions himself than his counterpart in unit or mass production. He therefore spent more time on his formal social duties as the head of a large organization, which are so important to its corporate life. Also, the emphasis of his job was on the co-ordinating and controlling elements in the management process. He did, of course, make the relatively few decisions that depended almost entirely on value judgments, many of them in the field of human relations. This meant that, on the whole, decisions about people were taken at a higher level.

(5) Management performance became easier to measure as technology advanced. This, together with the need for technical competence in management staff, made selection for promotion much less subjective and reduced the strain and stress associated

with promotion. The tendency for one individual to attach himself to another, and rise or fall with him, was much less marked.

(6) In general the behaviour of managers was conditioned more by their position in the organization than by their personalities. An extreme example of this was found in one large continuous-flow plant, where there had been 100 per cent turnover of managerial and supervisory staff above the rank of foreman in three and a half years. Some of the staff had been promoted from one job to another, but many had come in during that period from the company's other production units, from universities, or from outside firms. In spite of this the factory operated very successfully and it seemed that, in all vital respects, one plant manager behaved in very much the same way as his predecessor had done or as his successor was likely to do.

The effect on human relations

Technical complexity has been defined on p. 12 as the extent to which control can be exercised over the physical limitations of production. At the beginning of the technical scale, it seemed, physical limitations were so difficult to control that little attempt was made to do so; consequently people were subjected to relatively little pressure. No one, for example, tried to hustle the engineers engaged on the development of a complicated piece of equipment; on the contrary, it was traditional that they were unlikely to work well 'with a gun at their backs'.

In large-batch and mass production, continuous efforts to push back the limitations of production put considerable pressure on employees. Targets were set progressively higher, incentives of many different kinds were offered, and production tended to proceed by drives. But in the last resort the pace was still set by the amount of effort the operators were prepared to put into the job.

At the top of the scale the exercise of control was so mechanical and exact that pressure on people was again at a minimum. Productivity was related only indirectly to human effort; on the whole, people were hard-pressed only when things went wrong. Moreover, the plant itself constituted a framework of discipline and control. Any demands on the operators were in fact made by the process rather than by supervision. Most of those interviewed seemed to resent authority less when exercised over them by the process than by a superior.

As technology advances the entire concept of authority in industry may have to change. In process firms the relationship between superior and subordinate was much more like that between a travel agent and his clients than that between a foreman and operators in mass production. The process foreman's job was to arrange things within limits, set by the plant, which both he and the operators understood and accepted. This common understanding and appreciation of the demands of the job is much the same as that found in unit production.

There is, for example, a different attitude to time-keeping. In the mass-production firms visited, the foremen had to work hard to prevent their operators from slipping off to wash their hands or to gather at the clock before finishing time; but in the process firms operators would arrive early for the night-shift of their own free will in order to allow the men they were relieving to get away for a quick drink at the local before closing time. The process workers were aware that the plant could not be left unattended and they themselves made the necessary arrangements.

There appear to be considerable differences between production systems in the extent to which the 'situational demands' create conditions conducive to human happiness. Managers and supervisors get more satisfaction from their jobs at the advanced levels of technology; from the operator's point of view, too, it would appear that the relaxation of pressure and the higher quality of relationships between supervisor and subordinates will more than compensate for any increased monotony and boredom arising from monitoring occupations.

VI. The Case Studies

Three detailed case studies were made in firms where production systems were mixed or being changed, because it seemed from earlier findings that the most serious organizational problems might be found there. The 'situational demands' arising at different points of the manufacturing process might well be incompatible or conflicting, as it might prove difficult to set up an organization through which they could all be met. In fact the organizational problems that arose in these three firms confirmed the findings of the earlier stages.

Factory A was one of the firms making diversely assembled products from standardized parts. A change had taken place from unit production to a system that relied partly on mass-production methods. This particular firm had in the past concentrated even more of its resources on research and development than is normal among unit-production firms; the keen competition in radio-communication equipment earlier in the century made this necessary. In this way it had built up a reputation for high quality which had been the key to its outstanding success.

Soon after the last war this firm had been acquired by a large and important industrial group with wide interests outside its specialized field, and with a reputation in which 'production efficiency' featured more prominently than 'the best'. While the new owners did not introduce any reorganization, Factory A felt the effects of the change in ownership, owing partly to the infiltration of new blood and partly to association with a different kind of tradition and culture. The change probably stimulated the attempt to make manufacturing operations more efficient by introducing techniques of mass and large-batch production into what was essentially unit and small-batch production.

There was nothing revolutionary in the new approach to manufacturing; its main features were an increasing separation of production administration from the actual supervision of production operations, and a tightening of controls. The shop supervisors were required to operate to more detailed specifications; a Methods Department now told them how each piece of equipment had to be manufactured; a Production Control Department indicated when each phase of manufacture should

start and finish, and a Rate Fixing Department said what their labour costs should be. This is all familiar enough in mass and large-batch production.

In the case of Factory B, which produced pharmaceutical chemicals, developments during and after the last war led to changes both in objectives and in technology. Less dispensing is now done by retail chemists and more proprietary drugs and medicines are sent out by manufacturers ready for use. Preparing chemicals for sale has involved the development of line production; a different system of technology has been introduced alongside the plants in which the chemicals are produced. It has also meant that pharmacists are now employed in making as well as retailing chemicals. Thus, whereas in Factory A a change in manufacturing methods had taken place without any ostensible change in objectives, in Factory B a change in objectives had resulted in a change in methods.

In Factory C, a refinery, technical change was associated with a change in objectives but brought no fundamental change in the system of production. Little crude oil was distilled in this country before the last war, and originally Factory C had been mainly concerned with installation activities—importing, storing and distributing refined products—although between 1916 and 1945 a number of semi-automatic distillation plants had been built to refine imported oils further, mainly for lubricating oils, bitumen and paraffin wax. Factory C expanded rapidly after the last war, when it was decided to develop the distillation of crude oil in this country. The new distillation plants have more automatic controls than the older ones, but the system was always process production.

As might have been expected, technical change caused less organizational disturbance in Factory C than in Factories A or B.

Changing techniques but not objectives

Factory A had potentially the most difficult situation to contend with. Large-batch and mass production create an environment less conducive to human happiness than do process and unit production, so both Factories A and B were moving towards a more difficult situation; the change in Factory B was, however, associated with a considerable expansion in personnel, whereas in Factory A the people who had operated under the older system had to adjust to the new.

The changes in Factory A created a need for new status relationships between one function of management and another; the status of those concerned with production had to be increased at the expense of those employed on development and sales. The status of the draughtsmen deteriorated. Formerly they had been a vital communicating link between the development engineers and the craftsmen; now a number of specialist departments controlled production.

The status of the Inspection Department had been reduced too—contrary to expectation, for the importance of inspection normally increases in mass production. Here, however, the Inspection Department had previously combined the functions of inspection and testing; as it had to do more physical inspection its testing responsibilities decreased. In this kind of industry testing carries a higher status than inspection, so the department lost status. Moreover, the new production methods had reduced the production foremen's area of discretion, so that the work of the Inspection Department had become more of a routine.

In the past, professionally qualified people had been employed almost exclusively in the development departments. But now an increasing number were introduced into production itself, either as project engineers or as production supervisors. The older supervisors resented this infiltration and the greater pressure put upon them. They spoke nostalgically of the 'home from home' that the factory had been in the past.

Notwithstanding this resistance, however, the efficiency of production operations was increased, firstly because there was a fund of good human relationships on which to draw and secondly because men of exceptional ability and drive were associated with the changes. The Production Control Department was remarkably successful. At any time there might be a thousand items of equipment in production, each with upwards of a thousand components, and it was no mean feat to ensure that delivery dates were kept.

But in spite of this increased production efficiency a number of problems arose. It seemed to the research workers that the new owners allowed new methods to develop without considering whether these would still achieve the firm's objectives efficiently. The firm's reputation still depended on its development activities; the new methods, however, with their emphasis on production,

were more suitable for a different objective—the mass production of cheap, standardized goods—and the result was often an uneasy compromise between the two objectives. Thus, while some groups and individuals were still concentrating on top quality, others had become more concerned with cost reduction and the most economic use of resources. To keep up with the constant advances in electronics and maintain quality, the development and sales divisions often insisted on modifications to a design even after production had started. But the success of mass production is based on exact knowledge of detailed requirements at the beginning of operations, which did not always seem possible. The development workshops were on several occasions used for production work—an indication that the attempt to simplify and standardize was not completely successful.

It was interesting to compare Factory A with another firm operating in the same industry, where a similar attempt to modify techniques in order to increase production efficiency had been made and subsequently abandoned. Standards of performance had so deteriorated at all levels of the hierarchy that the firm's reputation for 'the best', on which its success depended, had been endangered.

A firm making agricultural implements was the most successful example of a combination of the mass production of parts with diversified assembly. This firm had to produce a wide variety of articles, but did not have to lay undue stress on top quality. It had the best of two worlds; it could reduce production costs and still meet individual requirements. In Factory A, however, while the problems of changing from unit to mass production were not insurmountable and had been tackled effectively, there was some doubt as to whether the new system was appropriate to meet the old objectives.

Two production systems in one factory

The problem for Factory B was to develop an organizational pattern which could meet with equal effectiveness two different, and in some ways conflicting, sets of 'situational demands'. The most serious difficulty seemed to be that of reconciling the related roles of line supervision and functional specialists.

The traditional line-staff pattern appears to work best in mass production. The personnel manager, for example, performed a

very useful function on the mass-production side in Factory B. Much pressure was exerted on the operators by the line supervisors, and the personnel department provided an effective safety valve. The line supervisors themselves recognized the importance of this safety valve and, despite the usual myth of line-staff friction, relations were good. On the plant side, however, there were occasional conflicts between the line supervisors and the personnel department because the activities of the personnel department cut across the close and intimate superior-subordinate relationships that are characteristic of process industry.

Differences in tradition between process industry and mass production also became exaggerated when the two systems were brought into contact. There were considerable differences in managers' and supervisors' dress, behaviour, and attitudes to the work between the two sides of the factory. Those interviewed spoke of 'the wall' between them. There was rivalry between the two sides, not only about their relative importance to the success of the enterprise, but also about their relationship with the chief executive and the board. A situation like this creates many problems of personal relationships for those at the top of the hierarchy, and when the study ended some of these were still unsolved.

New objectives for a process plant

Factory C had all the advantages of process industry mentioned earlier. The few organizational problems that had arisen from the new developments were not directly associated with technology. One problem had, however, arisen from the change in objectives: a reduction in the status of those responsible for the original installation activities—storage and distribution—in relation to those engaged in refining activities. Other problems had arisen because it had not been possible to build the newer plants less than two miles from the older ones. This led to difficulties of communication and to some administrative duplication. At the time of the research the administrative headquarters were on the older site. Thus the two sites were of almost equal status; the new plants had status in their own right, while the old plants retained status from their close association with higher management.

The organizational characteristics associated with process production were seen at their extreme in the most highly automatic

plants; for example, the ratio of managerial and supervisory staff to hourly-paid workers became progressively higher. Moreover, the distinction between line and staff functions, in particular between operating and maintenance staff, was even less clearly defined on the new site than on the old. However, the ratio of direct to indirect labour was much the same on both sites, apparently because the old plants required more maintenance while the new plants were more economical of both production and maintenance labour.

Compared with the other factories studied, the quality of personal relations in Factory C was very high. This case study provided an excellent opportunity to examine in detail how technical complexity, and the rational decision-making process associated with it, create a situation particularly conducive to good human relationships.

VII. Conclusions

How useful is the foregoing analysis of the demands imposed by the techniques of the production system? What contribution can it make to the study of management organization?

Firstly, the follow-up studies provided explanations of several organizational differences between production groups revealed by the background survey. Secondly, the analytical methods used isolated the forces at work in firms where technical innovation had resulted in disturbances in management organization.

Relating the case studies to the background survey

The case studies confirmed that variations in organizational requirements between firms are nearly always linked with differences in their techniques of production. For example, differences in two large-batch-production firms of approximately equal size were traced to the fact that one of them, although mainly producing large batches, also made a few articles to customers' individual requirements.

Thus it was possible to trace a 'cause and effect' relationship between a system of production and its associated organizational pattern and, as a result, to predict what the organizational requirements of a firm are likely to be, given its production system. For example, the following features can be traced to the technology of each system of production: a co-ordination of functions and centralization of authority in unit production; an extensive specialization and delegation of authority in mass production; and in process industry a specialization between development, marketing and production, combined with integration within each function and the co-operative character of decision-making.

The background survey showed that the successful firms approximated to the medians* of the group in which they had been placed. This indicates that the medians for each group represent a pattern of organization appropriate to the technology of that group.

* See Figure 2.

Are those responsible for building the organization in successful firms consciously aware of the demands of the technical situation, and does this affect their decisions? The findings suggest it is unlikely. In only three firms was there any definite evidence that organization was determined by a systematic analysis of 'situational demands'.

Organization appeared to grow in response to a number of stimuli. The 'organization conscious' firms tended to draw on the concepts of management theory, irrespective of how appropriate they were to the technical situation. Fashion was another important factor. Materials controllers and industrial engineers were becoming popular at the time of the research, and it was interesting to see how they spread from one firm to another. Moreover, organization had been modified to some extent in every firm to accommodate individuals—'empire builders' who distorted the pattern in their search for status, and misfits for whom some sinecure had to be found. These distortions often continued long after the people concerned had died or left the firm.

But although 'situational demands' did not determine formal organization, they appeared to have considerable influence on spontaneous or informal development.* In a number of firms formal organization did not satisfy 'situational demands' adequately, while informal organization did. Social scientists generally believe that a wide divergence between formal and informal organization is undesirable because it creates tension and conflict. Some of the firms in which organizational structure appeared to diverge from 'situational demands' might therefore be less successful because the informal organization deviated from the formal rather than because the demands of the technical situation were unsatisfied.

The most successful firms are thus likely to be the 'organization conscious' firms, in which formal organization is appropriate to the technical situation. Next would come the less 'organization conscious' firms, where informal organization mainly determines

* Formal organization implies the stable and explicit patterns of prescribed relationships in the firm, while informal organization implies the pattern that actually emerges from day-to-day operation.

the pattern of relationships. The least successful firms are likely to be the 'organization conscious' firms, where formal organization is inappropriate and deviates from informal organization. The research workers found instances of lack of success in 'organization conscious' process-production firms, where formal organization had been developed on a basis of traditional principles of administration which were more appropriate to large-batch and mass production.

'Situational demands' and technical change

The systematic analysis of 'situational demands' might well be used to predict the effects of technical changes on management structure and to plan organizational and technical change simultaneously.

The research showed that some technical changes have more effect on organization than others; their nature can be analysed systematically.

Examples were found of several different kinds of technical change. Changes from unit to batch and mass production were mostly associated with changes in objectives; a more standardized product was to be manufactured. Where, however, individual units were being produced on a basis of mass-produced, standardized parts, the production systems had changed while the objectives remained as before. The introduction of continuous-flow automatically controlled processes into the manufacture of solid shapes—for example, paper-board and mill-board, and food canning and packaging—had changed systems of production but not their objectives.

Two examples of transfer lines were found. In one firm this machinery had been introduced to produce barley-sugar sticks and had resulted in a change from batch to process production. But in the motor-car industry, transfer machines, although on a much larger scale, had not fundamentally changed the system of production; they produced only a very small percentage of the components for assembly.

To sum up: technical changes not associated with changes either in objectives or the production system would be unlikely to create very much disturbance in the organizational pattern. Where, however, the proposed technical change appeared to be likely to create new 'situational demands', these could be

foreseen by a systematic analysis of the new technology. Technical developments of the last twenty years, startling as they are in many ways, have not led to any entirely new system of production. They need not give rise, therefore, to organizational problems for which at least partial solutions cannot be found in the accumulated experience of industry.

Implications for teaching

It was hoped that this research would produce findings on which the management courses offered in the South East Essex Technical College could be appraised. At first sight this report may suggest that these courses have limited usefulness and can in some circumstances be misleading to students. The danger lies in the tendency to teach the principles of administration as though they were scientific laws, when they are really little more than administrative expedients found to work well in certain circumstances but never tested in any systematic way. This does not mean, however, that management theory has no value; it contains important and valuable information and ideas, provided its limitations are recognized and its principles subjected to critical analysis.

Management studies can so far identify symptoms and remedies. Alleviation of symptoms is useful in itself, but it is only through diagnosis that a physician can either be sure he is prescribing the right treatment or make any useful contribution to existing knowledge of disease. Thus it is important that in alleviating symptoms physicians do not neglect the problems of diagnosis. In the field of management studies many more descriptive accounts like that given here, of the circumstances in which different administrative expedients have proved successful, are required to supplement traditional teaching.